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Lifetime

ARMCO MULTI PLATE

for

**Bridges • Culverts
Large Drains**

CUSTOM-BUILT TO F



TO FIT YOUR DESIGNS

TO simplify your problem of designing and building large-size drainage structures, Armco engineers conceived and developed the idea of Multi Plate construction.

This modern, heavy-duty material consists of thick, corrugated iron plates, which are curved, punched and galvanized in the factory. These plates are delivered to your job in convenient "knocked-down" form. Local workmen simply bolt them together to fit whatever design you specify—whether it be a round or elliptical pipe, up to 10 feet in diameter and larger, or an arch of equivalent area.

Flexible corrugated metal structures have proved their adaptability and economy in actual service since 1896. So the basic principle of Multi Plate is *not new*. It has simply been *modified* on a sound engineering basis, so that you can obtain its many advantages in solving a *wider range* of your problems. In the years following its development, Multi Plate has won universal acceptance. Hundreds of installations are now serving satisfactorily in nearly every state in the Union, Canada, and foreign countries.

Left: Erecting 90-inch Multi Plate inside a failing stone arch in New York. Note how the curved plates are "staggered" and bolted together to form a continuous pipe.

ARMCO MULTI-PLATE PIPE *and* ARCHES

Let's Consider YOUR MAIN OBJECTIONS TO SMALL BRIDGES

As an engineering structure, the small bridge presents a number of unavoidable difficulties and objections that are appreciated by everyone. For example:

Detours

It usually takes weeks—often months—to build even the smallest bridge. This means a considerable hazard and delay for traffic, as well as the always annoying detour.

Traffic Hazards

With modern traffic moving at such high rates of speed, the small bridge has often proved to be the cause of fatal accidents because it crowds the roadway and deprives the motorist of valuable shoulder space.

Cost

The contract price of a small bridge is only one of the many items affecting its total cost installed. When the other items are included, the economic advantages of newer types of construction are more apparent.

Low Salvage Value

Besides requiring constant maintenance, the small bridge presents another source of worry because it has little or no salvage value—depending on type. When the location of a road is changed, a large part of your bridge investment must be left behind and where portions can be sal-



Above: Detours may involve the extra cost of erecting a temporary bridge, or they may cause an indirect toll on every taxpayer who has to drive extra miles over another road.

Items in Total First Cost Installed for any drainage structure

1. Purchase price of material
2. Transportation to site
3. Removing old structure
4. Excavation and backfill
5. Installing new structure
6. Detours and slow orders
7. Engineering and supervision

vaged, their use is not only limited but many times impractical.



Above: During construction the small bridge requires costly excavation, expensive forms and much engineering—all of which are a part of its total cost—and a sudden storm at the “wrong” time can quickly wash out all of this work.

Below: Abandoned bridges along roadways that are no longer used, speak a word of caution to those who are building for the future.



Left: The small bridge that is made narrow because of inadequate funds, congests traffic and endangers human life.



In Place of Bridges

MULTI PLATE IS

QUICKER - - -

MORE ECONOMICAL

ENGINEERS, contractors and public officials have been quick to accept the many advantages offered by Armo Multi Plate.

It can be installed in summer, winter, fall, or spring. Construction time is reduced from weeks or months to a matter of days because of quick, easy installation. In most locations there will be no need for a detour, since half of the pipe may be placed and covered before the existing structure or fill is removed—thus permitting free passage of traffic at all times. (See page 29.)

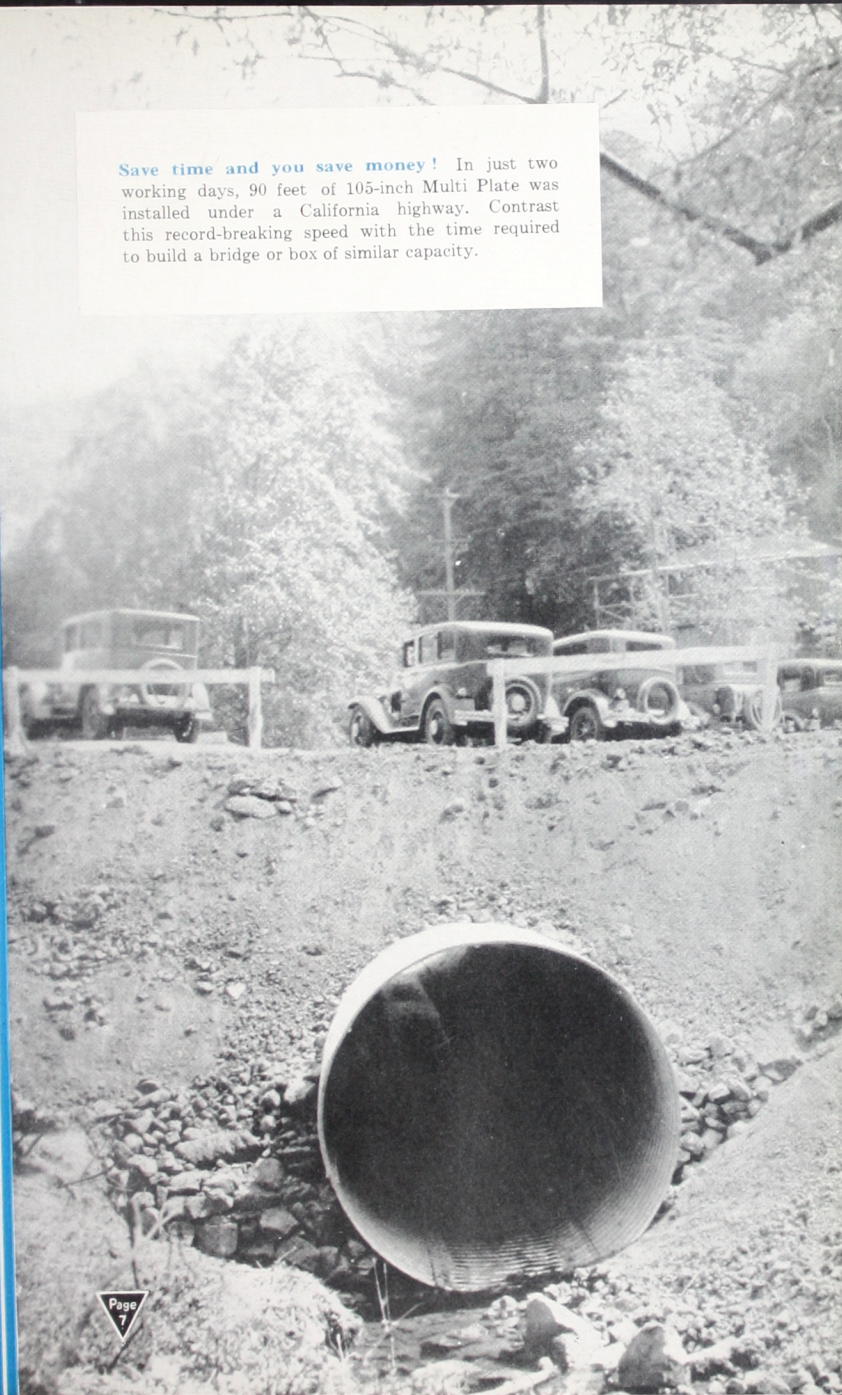
When you use Armo Multi Plate, you are doing your part towards the prevention of accidents—by providing a safe, full-width roadway that is free from dangerous obstructions.

In addition, you save money on many items affecting the total cost installed. You save the cost of expensive forms and extra equipment; you save the time, trouble and cost of a detour; you please the Public by carrying out necessary improvements, without inconvenience or "extra mileage cost" to the road user.

Adaptable to Change

Another important advantage of Multi Plate is that it can easily be extended, in case your road is ever widened. Also, in the event of relocation, Multi Plate can be taken out, stored and used again—either in its original form and purpose—or to serve an entirely new and independent need. (See page 29.)

Save time and you save money! In just two working days, 90 feet of 105-inch Multi Plate was installed under a California highway. Contrast this record-breaking speed with the time required to build a bridge or box of similar capacity.



. . . And It Introduces OTHER IMPORTANT ADVANTAGES



Maintenance Economy

The first cost is practically the last cost with Armco Multi Plate. Saving the money usually paid out for painting, re-flooring, fire damages, repairs and other forms of maintenance is a clear

gain that can be used for other purposes. In addition the cost of maintaining the roadway over Multi Plate is much less because uneven and bumpy approaches are entirely eliminated.

Balanced Design

As heavier-gage plates are ordinarily used in the bottom segment than in the top and sides, an economically "balanced design" structure is assured—with extra metal thickness where the greatest amount of wear comes from running water and stones.

Also, if it ever becomes necessary, the bottom segment may be replaced without in any way disturbing the rest of the pipe. This feature is not possible in any other type of drainage structure on the market today, yet its advantages are obvious.

Adaptability

Whenever large openings are required through existing embankments, Armco Multi Plate can easily be "jacked" through, without the danger and excessive cost of cutting an open trench. It can also be "threaded"

through structures which have been seriously cracked from traffic impact or uneven settlement—thus saving large sums in replacement charges without interrupting traffic, or injuring the roadbed. (See pages 2 and 3.)



Above: Installing a triple line of 10-foot Multi Plate Pipe under a government levee on the great Lake Okeechobee project, Florida. Unstable foundation conditions led Federal engineers to select Multi Plate over any other type.

Below: This 15-foot diameter Multi Plate pipe replaced a slab-type bridge, which collapsed as a result of an unstable foundation, under an Ohio road. The metal headwall can easily be extended or salvaged if necessary.



DEPENDABLE STRENGTH

For Every Service Condition

TO support present day loads and to provide for even heavier loads to come, every drainage structure should have a generous factor of safety against failure.

In Armco Multi Plate this important requirement is solved by two special features in its design. It is made of heavy, solid iron plates—ranging in thickness from $\frac{3}{16}$ -inch to $\frac{9}{32}$ -inch. In addition, these plates are formed with extra large corrugations—6 inches wide and $1\frac{1}{2}$ inches deep.

During erection, the plates are lapped and are held firmly in place by two rows of $\frac{1}{16}$ -inch galvanized bolts, which are staggered in the crest and valley of each corrugation. (See opposite page.)

Actual service proves that this rugged type of design insures uniform strength for even the most severe conditions—including high fills and unstable soils. Besides having great inherent strength, Multi Plate structures have sufficient flexibility, so that when properly installed, they can always obtain as much additional “side support” as they need to establish complete equilibrium and safety.

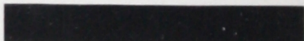
The increased strength resulting from flexibility has been proved by the unequaled performance of standard corrugated metal pipe, since its inception in 1896. Many thousands of installations are functioning 100%, under fills ranging from a few inches to more than 100 feet.

YOUR CHOICE OF FOUR GAGES

(Actual Thickness of Plates Shown)



No. 7 GAGE—Approx. $\frac{3}{16}$ -in. thick



No. 3 GAGE—Approx. $\frac{1}{4}$ -in. thick



No. 5 GAGE—Approx. $\frac{7}{32}$ -in. thick



No. 1 GAGE—Approx. $\frac{9}{32}$ -in. thick



ACTUAL SIZE

View showing how the heavy corrugated plates are lapped and bolted together. The specially-designed bolt-head fits both crests and valleys of corrugations. Simplifies erection. Can't jar loose.

Theft-proof.

Extra-Thick

ARMCO INGOT IRON PLATES

Assure A LIFE-TIME STRUCTURE

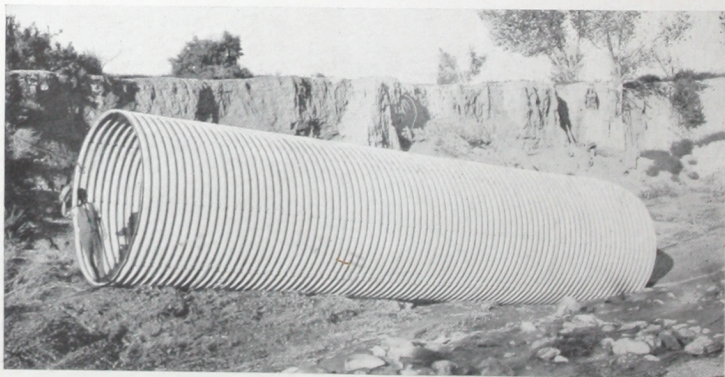
ONE of the most important questions to be answered in determining the ultimate value of any drainage structure is "How long will it last?" Dependable service year in and year out is a matter of primary concern.

With more than a quarter century of actual drainage service to date, largely on 16-gage material ($\frac{1}{16}$ -inch thick), Armco Ingot Iron has already proved its ability to render satisfactory and economical service.

It was logical then that this same long-lasting iron should be

used in Multi Plate. The plates are three to four times as thick as 16-gage and they are protected by full-weight coatings of high grade zinc.

From these known facts, it seems reasonable to predict that Armco Multi Plate will give life-time service. And another big advantage is this—the uncertain personal element in field control is largely eliminated because Multi Plate quality is built right into the plates before they are shipped. It is always the same—always dependable.



Before backfill could be placed, this huge Multi Plate Pipe was washed 300 feet downstream by a sudden flood in Utah. Afterwards, it was simply pulled back in place and reinstalled. It has resisted heavy floods ever since—without damage.

A PLAIN STATEMENT

About ARMCO INGOT IRON

PURE IRON—Armco Ingot Iron—was developed in 1906, to meet the specific need for a low cost metal which would effectively resist rust. Today, its unequalled performance in actual service offers definite proof that the pure iron theory is fundamentally sound.

Armco does not indulge in sweeping, ungrounded claims about the superior durability of its metal. Nor are statements made which are based only on the service rendered by a few favorable installations. In all fairness to the buyer, Armco presents the true comparative facts, obtained by actual field investigations of many thousands of drainage



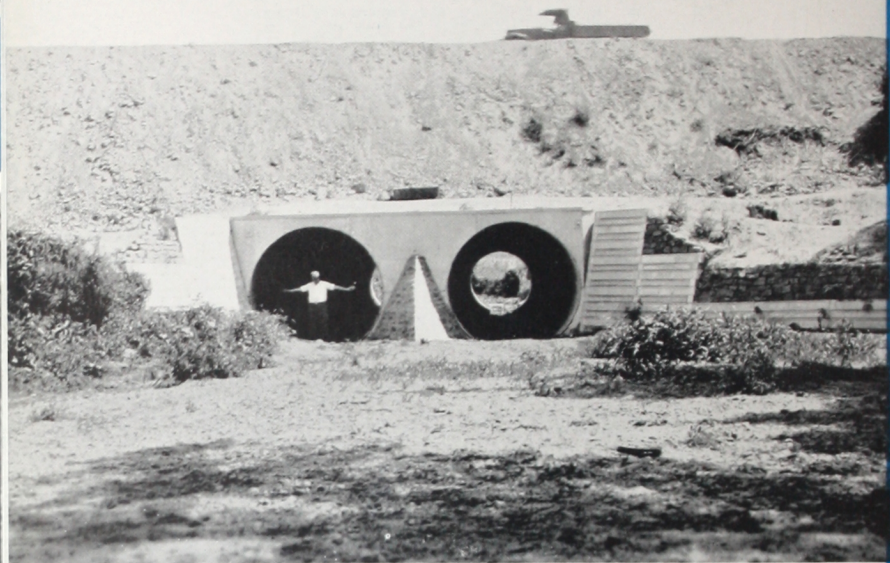
structures, in nearly every state in the Union.

These available facts prove conclusively that, when measured on the basis of "average performance" under all conditions encountered in drainage service, Armco Ingot Iron lasts longer than any other inexpensive culvert metal which has been in service long enough to justify a comparison.

The cost of drainage is so small, compared with the total cost of a road, that most engineers and public officials don't like to gamble. They demand Ingot Iron on the basis of "proved performance" and uniform quality, which are always assured by the blue Armco trademark.



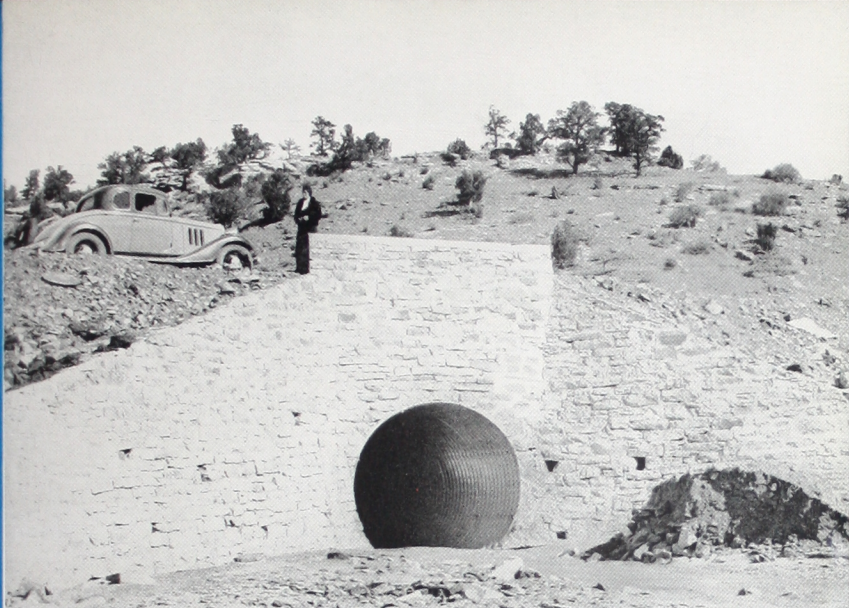
One truck can easily carry enormous footages of Multi Plate because the plates themselves occupy so little space. This feature means unusually low transportation and handling costs—as well as certain delivery to even the most out-of-the-way places.



Above: A 25-foot fill means nothing to this double line of 10-foot Multi Plate pipe, installed in New York. It has strength to spare. Notice the special metal headwall and the use of Metal Cribbing for wingwalls.

Below: Lifetime service is assured by this installation of 105-inch diameter Multi Plate pipe at the junction of two California highways. Note the unusual method of handling this parallel stream with a concrete headwall.





Above: Under a Colorado highway, this big 10-foot Multi Plate pipe, with its economical *stone headwall*, fits perfectly into the natural landscape. It replaced a steel bridge, which was too narrow and badly out of alignment.

Below: With only a few feet of cover, this 135-inch Multi Plate pipe easily carries the modern traffic of a Wisconsin road. The headwall was eliminated for reasons of economy, safety, and to simplify future widening.



WHERE ARMCO MULTI PLATE IS BEING USED



In Highway Construction

Small bridges	Undercrossings
Bridge replacements	Cattle passes
Large diameter culverts	Stream enclosures
Extensions to existing bridges, boxes, etc.	

In Railway Construction

Small bridges	Undercrossings
Trestle replacements	Cattle passes
Arch re-linings	Pedestrian subways
Large diameter culverts	Special drainage outlets

In Municipal Construction

Small bridges	Undercrossings
Large storm sewers	Pedestrian subways
Stream enclosures	Tunnel linings
Well casings	Special conduits
Extensions to existing bridges, boxes, etc.	

In General

Wherever a large waterway opening is required, Armco Multi Plate is appropriate in either a single or multiple installation. It offers definite savings in construction and maintenance costs, besides providing a maximum return on your investment in extra years of trouble-free service. Our engineers are prepared to show you complete data, covering the design of Multi Plate for individual conditions.

WATERWAY AREAS

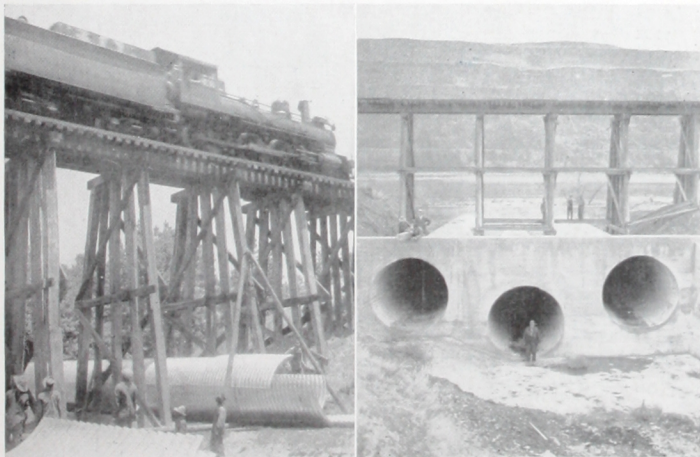
TABLE No. 1—ACRES DRAINED BY THREE SIZES

(Based on Talbot's Formula $A = C\sqrt[4]{M^3}$ in which A=area of waterway opening in square feet; C=a constant and M=acres drained.)

Diameter in Inches	Area of Waterway in Sq. Ft.	Mountainous Country C=1	Rolling Country C=1/3	Flat Country C=1/5
90	44.2	160	670	1400
105	60.1	240	1000	2100
120	78.5	340	1450	3000

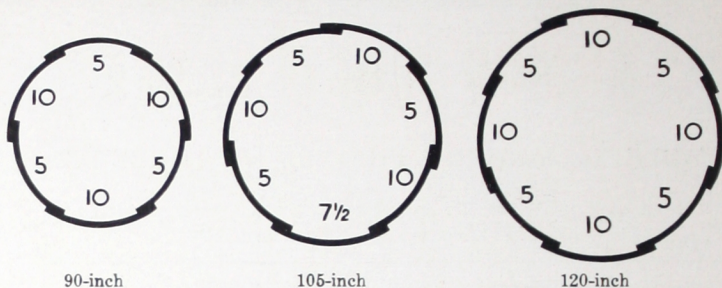
NOTE: Information on other sizes will be furnished on request. The above table is based on a maximum rainfall of probably 4 inches per hour, so correction should be made for local rates of rainfall.

No More Maintenance!



Left: Replacing a 35-foot high trestle under a main line railroad in Louisiana with 90-inch Multi Plate. **Right:** Triple 10-foot Multi Plate eliminating trestle on a transcontinental railroad in the northwest.

End Views of Three Diameters*



In making 90-inch Multi Plate, six plates are required to complete a circle; seven plates are needed for 105-inch, eight plates for 120-inch, etc. All standard plates are 10 feet long, except that every other plate at the ends of the pipe is a half or three-quarter length, depending on the diameter. There is no complete circumferential seam, since the plates are staggered as shown below.

Plan Views Showing Arrangement of Plates*

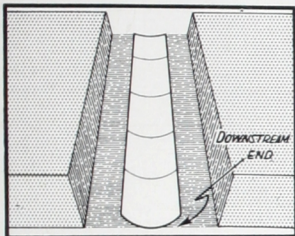
For even lengths
(Such as 30', 40', etc.)

For uneven lengths
(Such as 35', 45', etc.)

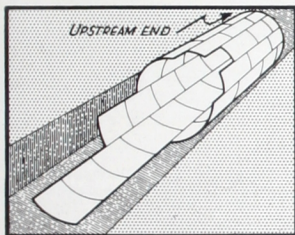
SIDE	10				10				90-INCH	10				10				5	SIDE
SIDE	5	10	10	10	5	5	10	10		10	10	5	SIDE						
BOTTOM	10				10					10				5	BOTTOM				
SIDE	5	10	10	10	5	5	10	10		10	10	5		SIDE					
SIDE	10				10					10						SIDE			
TOP	5	10	10	10	5	5	10	10		10	10	5					TOP		
SIDE-TOP	5				10				10				5	SIDE-TOP					
SIDE	10				10				10				5		SIDE				
SIDE	5	10	10	10	5	5	10	10	10	10	5	SIDE							
BOTTOM	7½				10				5	7½						BOTTOM			
SIDE	10				10				10				5				SIDE		
SIDE	5	10	10	10	5	5	10	10	10	10	5		SIDE						
SIDE-TOP	10				10				10					5	SIDE-TOP				
SIDE	5				10				10				5	SIDE					
SIDE	10				10				10				5		SIDE				
SIDE	5	10	10	10	5	5	10	10	10	10	5	SIDE							
BOTTOM	10				10				10				5			BOTTOM			
SIDE	5	10	10	10	5	5	10	10	10	10	5		SIDE						
SIDE	10				10				10								SIDE		
TOP	5	10	10	10	5	5	10	10	10	10	5	TOP							

*Numbers in sketches show length of plates in feet.

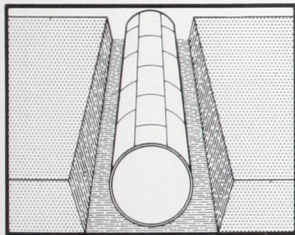
HOW TO ERECT FULL-ROUND ARMCO MULTI PLATE



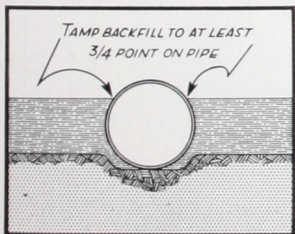
1 After the foundation has been prepared, the bottom plates should be placed in position beginning with the downstream end, for the full length of the pipe, if possible. (See sketches on opposite page.)



2 Next add the side plates, working downstream, and using only sufficient bolts (about 10) in each seam to hold the plates in position. The nuts on these bolts should not be tightened until the circle is completed.



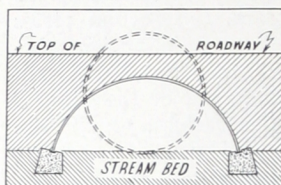
3 Following the installation of the top plates, all remaining bolts may be placed and tightened. In assembling the sections, be sure that all downstream plates are placed *outside* adjacent upstream plates. (Like a shingle roof.)



4 The fill material should be thoroughly tamped as deposited up to $\frac{3}{4}$ the height of the pipe; and should be placed fairly evenly on the two sides up to a height of 10 to 15 feet over the top.

MULTI PLATE ARCHES

Where Headroom is Limited



IN many locations there may not be enough clearance to install a full-round Multi Plate of the proper area. For such conditions, Multi Plate arches provide a practical and economical solution to your problem. They may either be used complete, with smooth iron base plates and metal aprons, or

they may be set in bases of concrete, timber or masonry. Properly designed and installed, they constitute strong, long-lasting waterways with all of the other advantages enjoyed by the full-round type. (See pages 4 to 13.)

Multi Plate arches can be designed in various spans to meet local conditions. Additional waterway area may sometimes be secured by depressing the floor of the arch, or by building the footings higher than the streambed. Another common method is to increase the total span, by installing two or more Multi Plate arches side by side. Spandrel and endwalls, where desirable, may be built of metal, concrete, rubble work, or ordinary rip rap.

TABLE No. 2

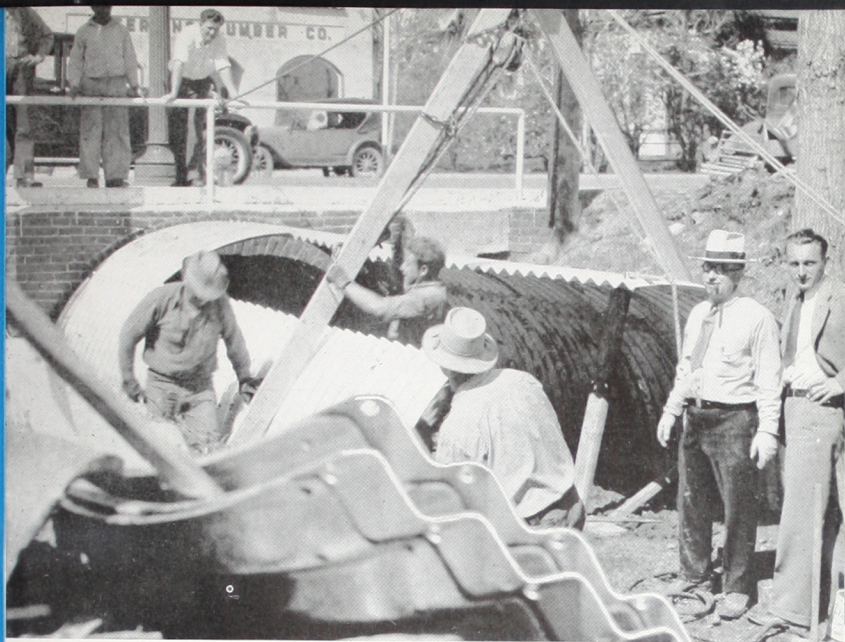
ACRES DRAINED BY TYPICAL SIZES

Based on Talbot's Formula $A = C \sqrt[4]{M^3}$ (See Page 17).

Span and Rise in Inches	Area of Waterway in Sq. Feet	Mountainous Country C = 1	Rolling Country C = 1/3	Flat Country C = 1/5
90"-47½"*	23.5*	67	290	580
120"-62½"	41.0	140	600	1200
150"-77½"	63.5	250	1090	2200
180"-92½"	90.5	410	1750	3500

*Area is slightly larger than half-circle because the rise is more than half the diameter.

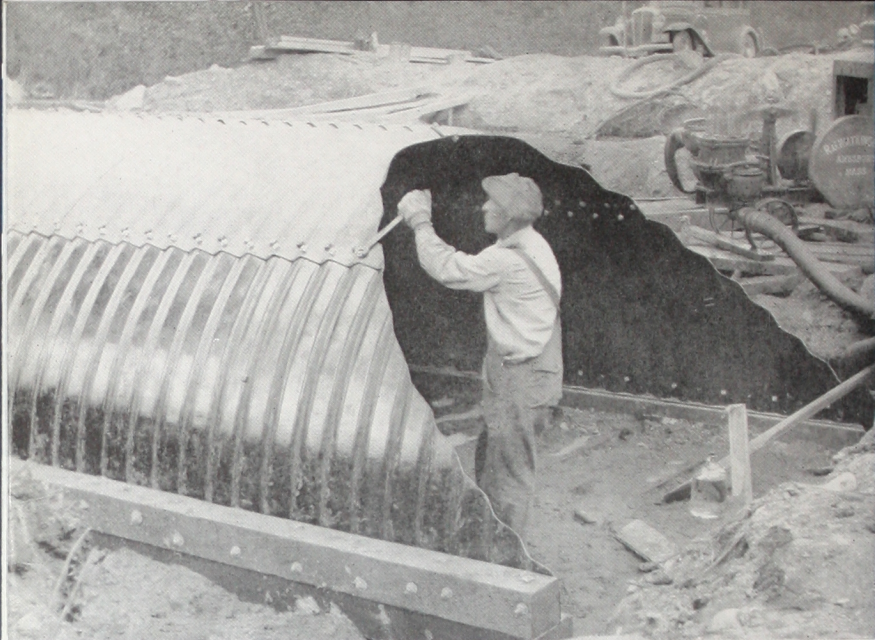
NOTE: Data on other sizes furnished on request. Table is based on a rainfall of 4 inches per hour. Correction should be made for local rates of rainfall.



Above: Unskilled labor installing a 10-foot span Multi Plate arch, to cover 300 feet of an open stream in Redding, California. As a result of this improvement, additional land was provided for a new post office.

Below: This attractive Multi Plate arch, installed under a Pennsylvania highway, is skewed 75°. Its thick iron plates carry all of the load, while the stone spandrel and wingwalls lend a natural appearance.





Above: Erecting a 10-foot span Multi Plate arch on a timber base, under a Massachusetts road. Both ends of the arch were bevelled to fit the slope, which was then rip-rapped to dispense with headwalls.

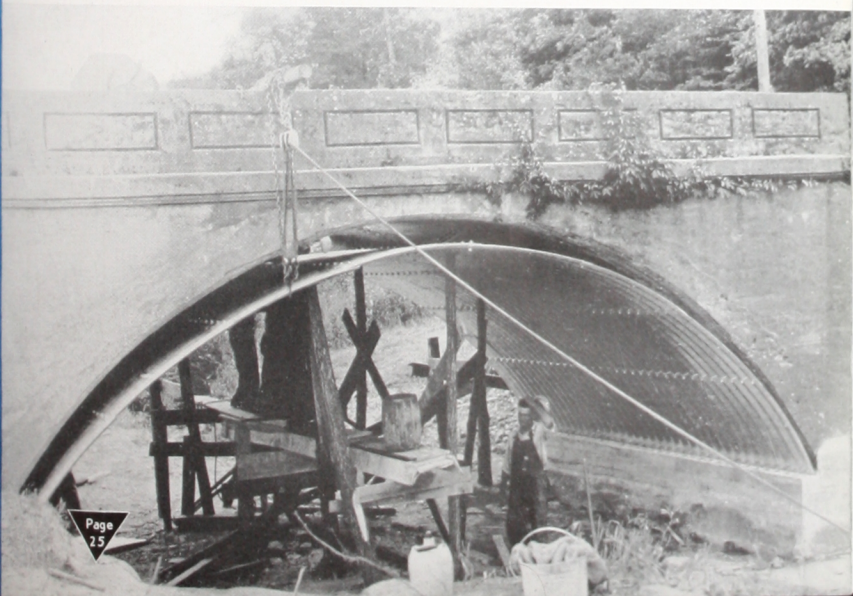
Below: A wider road, a safer structure and no upkeep expense, are the advantages provided by this 10-foot Multi-Plate Arch in Minnesota. The flat metal bottom assures a stable foundation in miry soils.

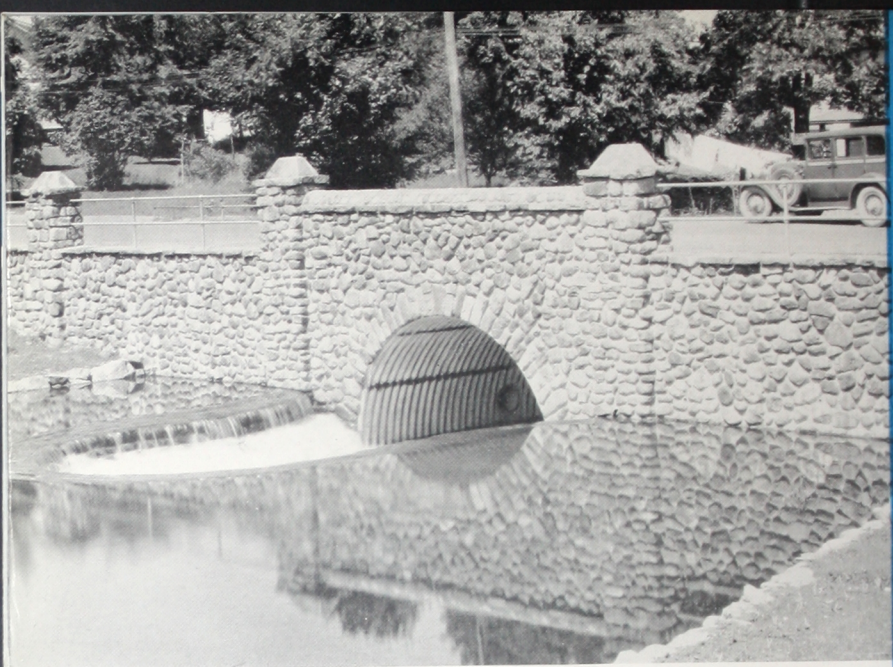




Above: Extending a small concrete bridge with an Armco Multi Plate arch, in Clinton County, Indiana. The arch was placed on a slight skew by offsetting the plates. Erection proceeded rapidly, in spite of winter weather.

Below: By using Armco Multi Plate, the officials of Ripley County, Indiana, were able to replace this failing bridge at less than one-half the cost of removing it and building an entirely new structure. The new arch is set on *concrete footings*.





Above: This attractive Multi Plate arch, located in New York, was used to extend an old stone structure and provide a safe, full-width roadway for traffic. It has a span of 15 feet, with a special drop inlet.

Below: Who wouldn't be proud of a bridge like this—made of Armeo Multi Plate—with beautiful spandrel and end-walls built of natural stone. This twin installation is located in Connecticut and is built on a skew.





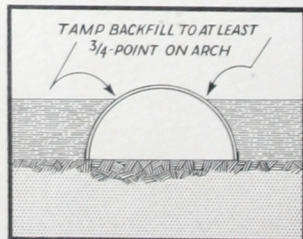
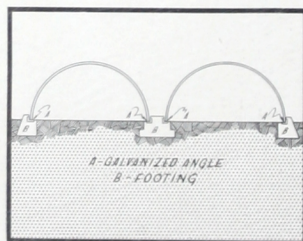
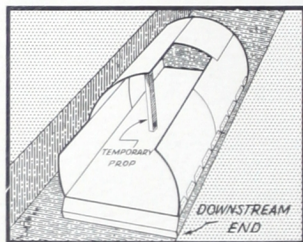
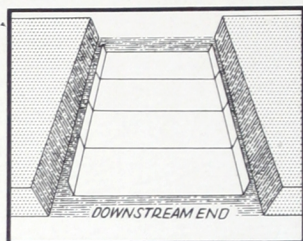
Above: Notice how perfectly this Armeo Multi Plate arch harmonizes with its natural surroundings. In Vermont, as elsewhere, engineers and road officials are finding that Multi Plate lends itself perfectly to artistic design.

Below: This quadruple Multi Plate arch bridge, with its handsome concrete spandrel walls, has a combined span of nearly 80 feet. It is being installed under an Ohio state highway, to drain the overflow from a nearby river.



HOW TO ERECT

Multi Plate Arches



WHEN base plates are used, care should be taken in preparing the foundation to insure uniform bearing throughout the entire length. Then add the first course of side plates (beginning with the upstream end) and bolt them securely to the base plates. Temporary props will often prove helpful for holding the plates in position until a connection can be made. In placing additional side and top plates, the same general principles applying to the erection of full-round Multi Plate Arch should be followed.

Where no floor is required, concrete footings provide a satisfactory foundation for Multi Plate Arches. These footings may vary in design, according to the size of the arch, the load it must carry and the character of the soil. Ask your Armco representative to show you typical footing designs that have been worked out to meet various service conditions. It is also suggested that you check these designs with your Bridge Engineer for any possible recommendation he may have for local requirements.

Like full-round Multi Plate, the fill material should be well tamped to at least the $\frac{3}{4}$ -point on the arch and should be deposited as evenly as possible over the top.



Above: By erecting and backfilling one-half at a time, this Armco Multi Plate arch was installed under the heavily travelled Dixie Highway, as well as a traction line—without interrupting traffic.

Below: Unforeseen conditions developed after the erection of a 10-foot Multi Plate pipe, in DeKalb County, Georgia. So the pipe was dismantled and the same plates were used to build these two half-circle arches.



GAGE COMBINATIONS AND WEIGHTS

ARMCO Multi Plate is available in any (or a combination) of four standard gages for each diameter. This custom-built feature gives the engineer an opportunity to design a structure that is adequately suited for the particular problem at hand. As an example: in 90-inch pipe, where 6 plates are required to complete a circle, all of the plates can be made of either 7, 5, 3 or 1-gage material; or five

of the plates can be 7-gage and one 5-gage; or three plates can be of 5-gage material and three of 3-gage, etc., etc.

Heavier gage (thicker metal) obviously provides greater strength and durability. Where a combination is desired on the same job, heavier gages are generally used in the bottom because that is the portion subjected to the most wear.

Gage	Approximate Thickness of Metal	Approximate Weight of 10-ft. Plate
No. 7	$\frac{3}{16}$ -inch	385 lbs.
No. 5	$\frac{7}{32}$ -inch	447 lbs.
No. 3	$\frac{1}{4}$ -inch	510 lbs.
No. 1	$\frac{9}{32}$ -inch	573 lbs.

Note: Above figures do not include weight of bolts.

WEIGHT PER FOOT

To estimate the approximate weight per foot of any particular diameter, simply apply the above table of weights to the number of plates required for each gage and divide by ten. The following example is of 90-inch pipe:

$$\begin{array}{rcl}
 5 \text{ plates } 7\text{-gage} & = 5 \times 385 & = 1,925 \text{ pounds} \\
 1 \text{ plate } 5\text{-gage} & = 1 \times 447 & = 447 \text{ pounds} \\
 \hline
 \text{Approximate weight} & & \\
 \text{of ten-foot section} & = 2,372 & \text{pounds} \\
 \text{Approximate weight per foot} & = 237.2 & \text{pounds}
 \end{array}$$

The number of plates required to complete a circle, in any of the three common diameters, is discussed on page 18.

HELPFUL HINTS

On Erection

Complete instructions for assembling each job will be furnished on request. The following suggestions are made mainly to pass on the experiences of others in erecting Armco Multi Plate.

LABOR

Four common laborers under the direction of a competent foreman are sufficient for ordinary installations. On very long lines, two or more crews may well be employed.

TOOLS

For holding the bolts, several L-shaped wrenches with square sockets should be available. Socket wrenches can also be used effectively for tightening. In adjusting the plates to match the bolt holes, a fence jack or several light chains with end hooks and turnbuckles can be used to advantage.

ACCESSORIES

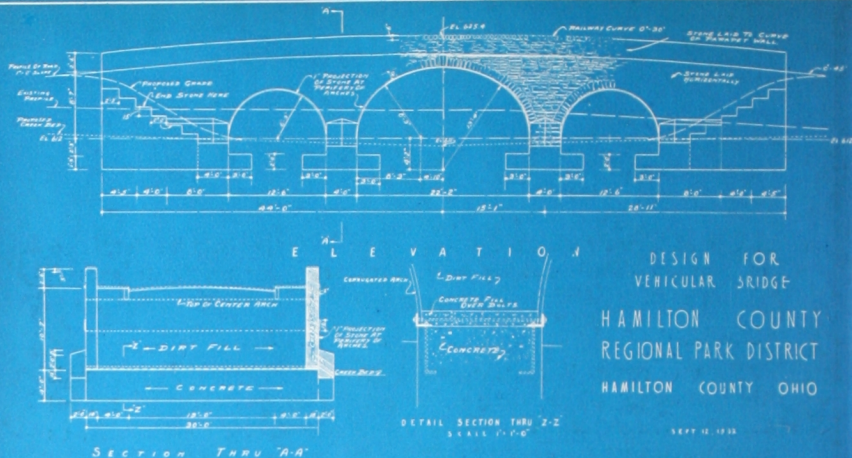
A few half-inch iron rods pointed at one end and several feet long should be on hand, as well as some drift pins, two ordinary pry bars and one or two fairly heavy hammers. Three or four one-gallon buckets will prove convenient for keeping bolts and nuts separate.

EQUIPMENT

On the larger installations, some form of lifting equipment, such as an A-frame or simple derrick capable of handling 600 pounds, will speed up erection.



These two Multi Plate arches, with mitred ends, will carry a 12-foot fill on the new highway above San Fernando, California. One protects the big steel penstock of the Los Angeles aqueduct. The other provides an opening for the aeration spillway.



Above is the design for the handsome Armco Multi Plate bridge shown on the front cover

To sum it all up

- 1 AS A CONSTRUCTION MATERIAL—Armco Multi Plate can be designed to fit local conditions, with dependable results.
- 2 AS A MATTER OF ECONOMY—Armco Multi Plate offers you definite savings in construction and maintenance costs.
- 3 AS A FINISHED STRUCTURE—Armco Multi Plate can be counted on to last a lifetime, without ever becoming obsolete.
- 4 AS A MATTER OF SERVICE—Armco Multi Plate is backed by a staff of experienced engineers, who are ready to cooperate with you.

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